IMPROVEMENT AND RENEWAL OF MEASUREMENT TECHNOLOGIES OF INDIVIDUAL EXPOSURES IN EDF NUCLEAR INSTALLATIONS

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Introduction

Since 2003, Electricité de France (EDF) has engaged a programme whose aim is to improve measurement devices used to follow individual exposures of workers in its nuclear installations. In the respect of new regulatory requirements and taking into account technological progress and feedback experience, EDF has undertaken to replace, review or implement equipments needed to measure and to interpret levels of external exposure (gamma, neutrons, extremities) as well as levels of external and internal contamination.

This article presents the adopted methodology, the chosen technologies, the reasons that led to their selection, as well as the problems encountered.

Measurement of external exposure by gamma irradiation

Passive dosimetry

Since the seventies, in EDF, the whole body gamma passive dosimetry was performed with silver emulsion film badges (KODAK ©). In 2001, in order to anticipate future regulatory requirements and following the announcement of the stopping of production of films by the supplier, EDF launched a study on the opportunity to change of technology.

After a review of available passive dosimetry technologies, comparative trials were performed between the film and three other devices - TLD (Thermo-Luminescence), RPL (Radio-Photo-Luminscence) and OSL (Optically Stimulated Luminescence) - in partnership with AREVA, CEA and medical X-rays departments. This comparative study took place in 2002 and showed that all technologies provided compatible dosimetric estimates (within a 20% range). The OSL dosimeter was finally selected because it presented the best compromise for EDF in terms of overall performance and costs of implementation.

Since February 2006, the OSL dosimeter has also replaced the silver film. It is used to measure whole body exposure, but also to monitor extremity exposure. Doses are recorded from 0,10 mSv with a reading step of 0,05 mSv. The replacement of passive dosimeters took place in two steps with a first “pilot” step on 3 plants, and then a second step of generalization to all EDF plants. Only few minor adjustments related to the deduction of the background radiation were made during the first month.

Operational dosimetry

In parallel, operational dosimeters have also been renewed in all EDF installations. Before 2005, several electronic dosimeters were used and were quite inhomogeneous (SAPHYMO DOT 80, SAPHYMO DOX Si 1G, SAPHYMO DOX SI 2G, MGPi DMC 90, MGPi DMC91, MGPi DMC100, MGPi DMC2000S). Between the end of 2005 and the beginning of 2008, they were all replaced by the electronic dosimeter SAPHYMO Saphydose gamma i: this model was selected because of its overall performance (energy response in dose and dose

rate) and its cost. 18 000 dosimeters SAPHYMO are currently used in the EDF plants in operation.

The implementation of this new generation of dosimeters needed some adjustments.

- Even if the dosimeter SAPHYMO respects the requirements associated with electromagnetic waves, it appeared that it could be disturbed (dose increment) by mobile phone systems. Moreover, it showed a high sensitivity to electrostatic frictions. The firm SAPHYMO was contacted to solve both problems and improve its equipment. From now on, dosimeters are insensible to telephony systems used at EDF (DECT 50 mW). Nevertheless, interferences can always happen at the beginning of an arc welding.
- Dose values recorded by the SAPHYMO dosimeters are lower than those monitored by the previous technologies (notably DOT 80). Comparative trials performed in laboratories and during routine activities allowed confirming that the previous dosimeters overestimated doses.
- Finally, even if the dosimeters SAPHYMO offer the possibility to benefit from dose and dose rate alarms, it was shown that their audibility (in theory around 85 dB) was not always satisfying in noisy industrial surroundings. Even with an increased audibility value, EDF is still facing some problematic situations (for instance when workers are wearing ventilated protective suits).

When the dosimeters SAPHYMO were installed, EDF selected a recording threshold of 10 µSv with a reading step of 1 µSv. On the 1st of January 2008, when all plants were equipped with similar passive and operational gamma dosimeters, EDF decided to lower the recording threshold at 1 µSv. This technological modification and these successive changes of recording threshold and reading step caused an increase in the EDF total collective dose.

Finally, during the implementation of dose rate alarms, a significant number of dosimeters got triggered accidentally. The study of the origin and the type of events has led to review and improve some practices.

Measurement of external exposure by neutron irradiation

Until 2004, neutron dosimetry was considered as a complementary dosimetry, mainly linked with specific activities: fuel handling activities, activities in the reactor building or the boron meter local, handling of neutron sources... In EDF plants, it was evaluated either with a bubble dosimeters or a dosimeter DINEUTRON (with a dose integration mode) during activities in the building reactor.
Since the publication of a new regulatory requirement in December 2004, it is mandatory to wear both passive and operational neutron dosimeters.

To answer this new requirement and having in mind technical difficulties related to the evaluation of doses due to neutrons (variability of the conversion factors flux/dose, of the possible neutron spectra), EDF has launched a study of passive and operational dosimeters able to meet its needs.

<u>Passive dosimetry</u>
Following comparative trials, the dosimeter NEUTRAK T was chosen. This dosimeter is insensitive to gamma-rays and X-rays as well as others factors like temperature, humidity, electromagnetic waves… Moreover, it presents a large operation range covering energies from 40 keV to 40 meV as well as energies of thermal neutrons. Doses can be stored after

reading and re-read if needed. The theoretical recording threshold is 0,1 mSv with a reading step of 0,01 mSv.

Even if the recording threshold of 0,1 mSv was confirmed in laboratory, results of comparative field trials showed that the response of the NEUTRAK T is coherent with the response of a bubble dosimeter only above 0,4 mSv (read on the bubble dosimeter).

In order to get practical answers to this problem, EDG has engaged a study since the beginning of 2009.

Operational dosimetry

The regulation published in 2004 has forced EDF to abandon bubble dosimeters whose main drawback was not to allow the direct reading of doses (post-counting of bubbles formed in the neutron flux). EDF has also looked for an electronic dosimeter that would allow a simplified and direct reading of doses with a digital watch.

After a series of tests taking into account measurement performance, sensitivity to temperature, X-rays… and ergonomics, the dosimeter DMC2000GN (from the MGPi firm) has been selected. This dosimeter allows a display of neutron doses from the first microsievert and presents a good linearity. Dose alarms are adjustable from 0,01 mSv with a step of 0,01 mSv; dose rate alarms are adjustable from 0,1 mSv/h with a step of 0,01 mSv/h.

Between November 2008 and March 2009, 1000 new electronic dosimeters will be available in all EDF plants. They have been calibrated with conversion factors (flux/dose) defined from the considered activity and the neutron spectrum that may be encountered.

In the framework of its study, EDF will pursue dosimetric evaluations in actual working conditions in partnership with competent organisms. These trials will allow estimating deviations between the passive dosimeters NEUTRAK T and the electronic dosimeters DMC2000GN.

Measurement of extremity exposure by irradiation

In 2006, following several significant events which results in serious extremity exposure, it was found that the measurement technologies used at the collective and the individual level were not always effective to detect changes in dose rates as for extremity exposure.

This led to prepare a technical dossier to inform and raise awareness of EDF workers. This dossier reminds good radiation protection practices in case of the discovery of a mobile irradiating body, it also provides a methodology that allows a rough estimation of dose rates at a reference distance (between 10 mm and 5 mm) through an extrapolation of results obtained by measurements at a longer distance.

Measurement of external contamination: absorbed skin dose

In 2006, following an initiative of a pluralist working group, works on external contamination have been engaged with the objective to implement a common methodology to evaluate skin doses. The chosen method relies on the use of a Selectra-type contaminameter with a beta detector (IBP4A). A technical dossier including the calibration method and the operational procedures has been constituted.

Today, all occupational medicine services of EDF plants have been equipped with this technology.

In parallel, new adjustments have been performed on the monitors used to control the radiological contamination of workers from the exit of controlled areas (personal contamination monitor) to the exit of nuclear sites (portal radiation monitor). This was done to guarantee the detection of every external contamination that would justify a medical follow-up and an evaluation of the absorbed skin dose.

Measurement of internal contamination: whole body measurements

In EDF, internal contamination monitoring is ensured by the occupational medicine services who realise whole body measurements and if needed radio-toxicological analyses.

In 2004, the new regulation required that measurements of internal exposure are accredited by the COFRAC standard n°17025. This has helped to initiate a discussion that led to an upgrading of the existing whole body counters and a review of the software used to interpret results.

This technical upgrading allowed a standardization of the equipments. Thus, a comparison between 36 whole body counters showed an excellent coherence of the capacities of each device (differences were around 8% in the detection levels of caesium-137). Moreover, the participation in the inter-comparison study organised by the French Institute of Radiation Protection and Nuclear Safety (IRSN) confirmed the validity of the calibration method of these equipments.

Conclusions

The process of improvement/ renewal of measurement devices undertaken by EDF has allowed strengthening the quality of monitoring and the traceability of individual exposures. This was mainly achieved through the improvement of the quality and accuracy of measurements, the decrease of the recording thresholds and the setting-up of alarms.

However, investigations are to continue to identify causes of deviations between different generations and types of dosimeters. Otherwise, works on whole body counters and measurements portals will be finalized.

The next step will consist in strengthening the protection of workers with the development and implementation of a remote monitoring system (individual monitoring) and a centralized system of remote transmission of radiation protection beacons (collective monitoring).